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METHOD FOR MANUFACTURING A CAMSHAFT

The present invention relates to a method for manufacturing a camshaft according to the preamble of Patent Claim 1.

In the manufacture of camshafts in which the individual cams are not to be remachined after attaching and/or joining, one problem is how to join the individual cams accurately in the predetermined angular positions. Because of this difficulty, remachining is always necessary by grinding the cam contours after joining the individual cams or the tolerance limits of the cam positions must be determined by the joining process.

In a generic process for manufacturing camshafts, the present invention relates to the problem of eliminating remachining of the contours of the individual cams on the completely assembled camshaft.

In a generic manufacturing process, this problem is solved primarily through the process steps according to the characterizing features of Patent Claim 1.

Advantageous and expedient embodiments are the object of the subclaims.

The present invention is based on the general idea of combining the individual cams even before they are mounted on a shaft and joining them to this shaft to form a machining module, such that the individual cams are combined in their mutual arrangement in relation one another in which the cams are to be mounted on the finished camshaft. The final machining of the cams is performed within this machining module. When the cams are completely machined in this way, the cams are joined to the shaft of the camshaft within the machining module. This ensures that the desired mutual arrangement is maintained, i.e., that remachining is not necessary.

If only two cams are to be joined in a mutual fixedly predetermined arrangement on a shaft, then a corresponding machining module would consist only of these two cams and optionally axial spacers arranged between these cams.

Screws may be used as the means for joining the individual elements in a machining module for an axial bracing of the individual elements to one another, or after inserting dowel pins, screws may be used as tension means in machining and in joining. The screws may be in the form of countersunk screws. Instead of screws as tension means, any other tension means may be used when using dowel pins, such as the generally known tension means used in grinding and polishing.

With the inventive method, it is very advantageously possible to manufacture a camshaft having cams that are variably rotatable with respect to one another. In the case of one such camshaft known from European Patent 1 362 986 A1, for example, an inside shaft is mounted concentrically in an outside shaft, the two shafts being rotatable in relation to one another. First cams are fixedly connected to the outside shaft and second cams are fixedly connected to the inside shaft. These second cams are fixedly connected to the inside shaft, e.g., by connecting elements such as dowel pins that are secured in the inside shaft, penetrate through these cams radially and pass through the outside shaft through a recess provided there. Such second cams are rotatably mounted on the outside shaft. Subsequent machining of cams that have already been completely joined together - and are mutually adjustable to some extent - is difficult, so the inventive method has proven especially advantageous for this.

If a second cam, which must be provided with a radial borehole to receive a fastening element, e.g., a dowel pin, for an adjustable camshaft, is in a machining module to be

thereby positioned within the finished camshaft and to be rotatable, then this borehole can be produced while the respective second cam is in the machining module. This ensures an accurate angular position of the respective second cam within the finished camshaft.

Advantageous exemplary embodiments are illustrated in the drawing and described in greater detail below.

These drawings show:

Figure 1 a longitudinal section according to line I-I in Figure 2 through a machining module having a total of three cams,

Figure 2 a radial section through the machining module according to line II-II in Figure 1,

Figure 3 a longitudinal section through a machining module according to line III-III in Figure 4 with an alternative type of screw connection in comparison with the embodiment according to Figures 1 and 2,

Figure 4 a radial section according to line IV-IV of the machining module in Figure 3,

Figure 5 a longitudinal section through the machining module according to line V-V in Figure 4,

Figure 6 a longitudinal section through a completely joined adjustable camshaft having an inside shaft and an outside shaft.

Two first cams 1, 2 are joined together in one machining module, each first cam being situated on an outer end axially. Between these two first cams 1, 2 there is a second cam 4 which is located at the center of the

machining module and is spaced a distance axially away from the former via spacers 3 that are open at the circumference.

The total of three first and second cams 1, 2, 4 are linked together by two screws 5 that are approximately in opposition on the circumference. The two screws 5 are preferably designed as countersunk screws.

The cams 1, 2, 4 which are thus fixedly joined together in the machining module can be completely machined in this state, namely in particular with regard to their outside cam contours and their inside diameters.

The inside diameters of all the cams 1, 2, 4 are preferably selected to be the same in order to simplify machining.

The exemplary embodiment shown here concerns cams 1, 2, 4 for a camshaft having cams that are mutually variably adjustable with regard to their angular positions. The shaft belonging to cams 1, 2, 4 is made up of an inside shaft 11 and an outside shaft 12, which surrounds the former concentrically (6). The two shafts 11, 12 are rotatable in relation to one another. The relative rotation is usually accomplished by the fact that the inside shaft 11 is rotated inside the outside shaft 12. The two first cams 1, 2 which are situated on the outside axially in the machining module are intended for a tight seating on the outside shaft 2. The second cam 4, situated between these two cams 1, 2, is designed for a tight connection on the inside shaft 11. In the case of the tight connection with the inside shaft, the second cam 4 is provided with an inside diameter which allows a rotatable play-free bearing of the second cam 4 on the outside shaft 12 (Figure 6). The connection of the second cam 4 with the inside shaft 11 is accomplished by a fastening element which may be a dowel pin 13. This dowel pin 13 is secured on one end in the fitting borehole 7 in the second cam 4 and on the other end

in a borehole in the inside shaft 11, also passing through a recess 14 in the form of an elongated hole in the outside shaft 12. The fitting bore 7 of the second cam 4 is created while this second cam 4 is in the closed machining module.

The cams 1, 2, 4 have already been completely machined except for the machining operations performed while in the machining module.

After mounting the machining module on the outside shaft 12 of the camshaft, which is shown as an adjustable camshaft in the exemplary embodiment (Figure 6), i.e., after the end of machining and when there is a connection, e.g., a shrink connection, between the first cams 1, 2 and the outside shaft 12, the machining module is opened and the screws 5 and the spacers 3 that are open on the circumference are removed. The boreholes 10 remaining in the cams 1, 2, 4 necessarily lead to the advantage of a weight reduction in cams having these boreholes 10.

To accommodate the screws 5, which are inserted as connecting means in a machining module, a thread 8 may advantageously be provided on the optional spacers 3 (Figures 3 through 5). In the case of such an embodiment, at least two screws 5 may be used in opposite directions axially with regard to their head position and thread position to ensure a play-free and detachable arrangement in relation to the cams 1, 2, 4 (Figures 3 through 5). Accordingly, the spacers 3 must have at least four boreholes, at least two of which are designed as through-bores and two of which are designed as a thread 8. The advantage of this type of connection inside the machining module is first the possibility of reusing the spacers which are acted upon by the thread and are thus expensive and secondly the simpler machine-ability of all the cams 1, 2, 4.

In order to be able to machine an adjustable second cam 4 in the machining module to an inside diameter that is the same as that of the other first cams 1, 2, the outside shaft 12 must have a recess 9 having a reduced diameter in the area in which the second cam 4 comes to lie (Figure 6). The outside diameter of the outside shaft 12 is reduced to such an extent that the second cam 4 can be mounted on the outside shaft 12 rotatably and without any play in this area.

The radial circumferential surface of the cams 1, 2, 4 is understood to refer to their inside surfaces and the concentric outside surfaces and/or cam surfaces. The cam contours are especially important with respect to machining within the machining module.

With the finished adjustable camshaft illustrated in Figure 6 having an inside shaft 11 and an outside shaft 12, the first cams 1, 2 are tightly shrunk onto the outside shaft 12. The rotatable second cam 4, which is situated between these two first cams 1, 2 and is rotatable with respect to them, is fixedly connected to the inside shaft 11 by a dowel pin 13. To permit a relative rotation between the inside shaft 11 and the outside shaft 12, the dowel pin 13 in the outside shaft fits through a recess 14 in the form of an elongated hole in the circumferential direction.

All the features described in the description and characterized in the following claims may be essential to the invention either individually or combined in any desired manner.